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(12) # EUROPEAN PATENT APPLICATION

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(54) **A rigid arm single point mooring system.**

(57) A mooring device is disclosed, consisting of a single point mooring (SPM) - buoy or tower - and a rigid arm (15). The stationary part (4) of the SPM is anchored to the sea bottom. The rotatory part (8) of the SPM and the rigid arm (15) are free to rotate about the vertical axis (A-A) of the SPM. The rigid arm (15) is connected to the single point mooring by a hinge arrangement (9) pivotable about a horizontal axis (B-B). A further hinge may be provided in the rigid arm (15) dividing the rigid arm into two independently movable frames to allow for independent pitch and roll motions of the buoy and vessel in relation to the rigid arm. The vessel is connected to the rigid arm (15) by two tension members (6, 7) which could be chains, cables or bars. The rigid arm (15) is ballasted at the vessel end. The weight of the rigid arm (15) and its ballast (13, 14) and the loading on the tension members, combine to produce a restoring force and moment which prevent the vessel (1) from riding up to the SPM or jack-knifing of the assembly when the rigid arm (15) moves out of line with the centre line of the vessel (1).

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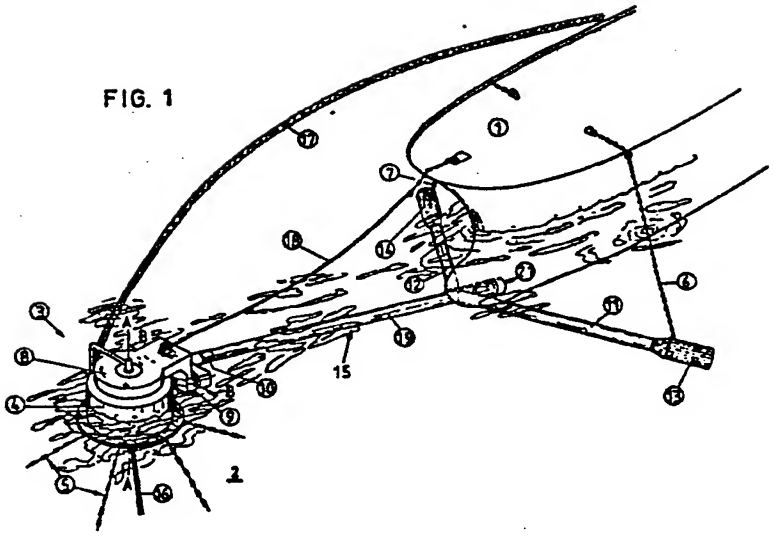
FIG. 1



A rigid arm single point mooring system.

The invention relates to a single point rigid arm mooring system, as described in European patent application no. 81201274.8 and concerns an improvement on that mooring system with respect to a single point mooring buoy, of which the principle is known per se from earlier patent applications, laid open to public inspection.

The single point mooring buoy referred to heretofore is usually a floating body anchored with anchor chains to the seabed. A rotating table on top of this buoy allows a vessel to be connected to this buoy and thus permits the vessel to swing freely around the buoy, whilst assuming the position of least resistance to the environment.

It is the general objective of the present invention to provide a novel type of mooring device for mooring a vessel on the surface of a body of water to the floor of that body of water. Compared with the single point mooring system, known from earlier patent applications, the buoy is here replaced by a construction (hereafter referred to as "tower"), which is fixed rigidly to the seabed. The tower may take any convenient shape, viz. be a single pile, a traditional truss type platform, jacket or a braced pipe type like the Tripod tower. This tower may be anchored to the seabed by either gravity or by piles.

The required flexibility for the mooring system is provided by the rigid arm mooring as described in patent application no. 81201274.8. In that application a Y-shaped rigid arm is disclosed having an axial hinge in the middle leg of the Y.

There are, however, in practice circumstances in which the flexibility thus obtained, is not sufficient. Therefore the rigid arm as described in the above patent application is here further improved by providing torsional flexibility in the rigid arm itself instead of providing a separate axial rotational joint between the tower and the rigid arm.

Accordingly the invention provides a mooring device for mooring a vessel floating on the surface of a body of water, comprising a single point mooring (SPM) fixed to the floor of said body of water, a rigid arm being connected with its one end to said SPM and with its

other end to said vessel, in which the connection between the SPM and the rigid arm occurs in a fixed or in a pivotable manner, said rigid arm being free to rotate about the vertical axis of the SPM, whereas the connection between the rigid arm and the vessel occurs via two pivotable tension members which are attached to the rigid arm at the vessel end, said pivotable tension members being separated by a certain distance.

In a first embodiment this is realized by an axial rotational connection which is located in the rigid arm.

It is of particular advantage that the rigid arm is Y-shaped.

Preferably the middle leg of the Y-shaped rigid arm is provided, at each of its ends, with an axial hinge, providing a flexible joint between the SPM and the rigid arm, and a flexible joint between one of the side legs and the remainder on the Y-shaped rigid arm.

The same degree of flexibility can be obtained by a mooring device, in which the rigid arm consists of two triangular frames interconnected via hinges allowing an independent hinging of the two frames in respect of each other and thereby an axial rotation of the rigid arm between the SPM-connection and the vessel-connection.

The above advantages can be obtained whether the SPM is constituted by a buoy or another anchoring system.

Accordingly in the first case the SPM is provided by a buoy whose stationary part is anchored to the floor of said body of water by means of chains, cables or the like.

In another case the stationary part of the SPM consists of a pile system (tower or the like) standing on or in the seabed around which pile system the rigid arm is rotatable.

An additional advantage can be obtained, if ballast weight(s) are located in the rigid arm.

Further it may be recommandable that the tension members consist of chains or cables which can be suspended through the anchor chain hawses of the vessel.

Preferentially there are hinges between the buoy and the rigid arm.

It may be of particular interest that there is a buoyancy chamber in the rigid arm.

Further and additional objects and advantages of the present invention will become apparent to those skilled in the art when considering the following detailed description and accompanying drawings, wherein like element have been given like numbers, in which is shown in

Fig. 1 a perspective view of an embodiment of the rigid arm of the invention, made in the form of a Y, in Fig. 1A a detail thereof;

Fig. 2 a schematic view of another embodiment of the rigid arm formed as a polygon and in which the SPM is formed as a tower;

Fig. 3 another embodiment of a tower used as SPM.

As may be seen from Fig. 1, the vessel 1 is moored to the floor of a body of water 2 by means of two tension members 6, 7, a rigid arm 15, a standard type of single point mooring constituted by a buoy 3, and one or more anchor chains 5. The single point mooring buoy 3 is of a type known to those skilled in the art, and consists of a buoy body 4 on which the turntable 8 is free to rotate about the vertical axis A-A of the buoy body 4. The buoy body 4 is attached to the floor of the body of water 2 by means of one or more anchor chains 5. The rigid arm 15 is attached to the single point mooring buoy 3 by means of the hinges 9. These hinges 9 allow relative movement between the buoy 3 and the rigid arm 15 about the horizontal axis B-B.

In Fig. 1 a first embodiment of the rigid arm 15 according to the invention is shown, which serves as buffer or distance holder between a single point mooring buoy 3 and a tanker 1, for example a storage tanker. The rigid arm has here the shape of a Y and has at two locations a hinge, viz. a first hinge 10 in the middle leg 19 of the Y near the buoy 3, and a second hinge 21 at the other end of the middle leg 19 where the fork begins, consisting of two side-legs 11, 12. By the positioning of these two hinges 10, 21 when seen in the drawing, the right hand side leg 11 and middle leg 19 are pivotable with respect to the left hand side leg 12. Both side-legs carry ballasts 13 and 14 at their extremities coupled to tension chains 6, 7 running upwards to the vessel 1.

The second hinge 21 consists of a disc 22 and a centring pin 23, which is located in a bore 24 in the middle leg 19 of the Y. The left hand side arm 12 on the Y is connected to the hinge 21 via an extension 26 connected to the disc 22; vide Fig. 1A.

As may be seen from Fig. 2 the vessel 34 is moored to the floor of a body of water by means of two anchor chains 37, a rigid arm 36, a rotational table 38 and a structure ("tower") rigidly attached to the seabed 33.

The rotating table 38 permits the vessel to swing freely around the tower to take up the position of the least resistance to wind and weather. The rigid arm pivots in relation to this rotating table around an axis y-y, through hinges 41, thereby allowing independent pitch motions of the vessel relative to the tower.

Hinges at the rigid arm end 12 and at the vessel connection point 13 allow for excursions of the vessel due to surge and sway. Roll motions of the vessel relative to the tower are allowed by two basically triangular frames 14 and 15, which are coupled together at their base and hence form the rigid arm 36. The hinges 47 and 48 allow the rigid arm to be "folded" in itself, around axis y-y and thus allow independent roll between the tower side end of the rigid arm and the vessel side.

The restoring forces required to balance environmental forces acting on the tanker is generated by a weight 49 which forms a part of the rigid arm. This weight can be permanent or mobile, depending on the application of the mooring system.

The product is carried up the tower through rigid piping 50 to the top of the tower , where a fluid swivel mounted on a second rotating table 40 allows for orientation of the piping towards the vessel. The piping continues to the vessel in a manner described in patent application no. 81201274.8.

In Fig. 3 is shown another embodiment of the tower or pile system 31 of Fig. 2.

The tower 60 consists of a number of piles 61, which are slanting and which are unitary in the upper part or top 62 of the tower, but spread out in the lower region near the sea bottom 63. Around the upper part of the tower is mounted the rotatory part or rotor 64 of the SPM. This rotor 64 is connected to the rigid arm 66, the latter being connected with its other end via chains 67 to the vessel 68.

The product is carried up the tower through rigid piping (not shown) to the top 62 of the tower 60, where a fluid swivel 69

mounted on a second rotating table 71 allows for orientation of the piping 72 towards the vessel 68. The piping 72 continues via sections 73-80 to the vessel 68.

C L A I M S

1. A mooring device for mooring a vessel floating on the surface of a body of water, comprising a single point mooring (SPM) fixed to the floor of said body of water, a rigid arm being connected with its one end to said SPM and with its other end to said vessel, in which the connection between the SPM and the rigid arm occurs in a fixed or in a pivotable manner, said rigid arm being free to rotate about the vertical axis of the SPM, whereas the connection between the rigid arm and the vessel occurs via two pivotable tension members which are attached to the rigid arm at the vessel end, said pivotable tension members being separated by a certain distance.

2. The mooring device of claim 1, further comprising an axial rotational connection which is located in the rigid arm.

3. The mooring device of claim 1 or 2, in which the rigid arm is Y-shaped.

4. The mooring device of claim 3, characterized in that the middle leg of the Y-shaped rigid arm is provided, at each of its ends, with an axial hinge, providing a flexible joint between the SPM and the rigid arm, and a flexible joint between one of the side legs and the remainder on the Y-shaped rigid arm.

5. The mooring device as claimed in claims 1 or 2, in which the rigid arm consists of two triangular frames interconnected via hinges allowing an independent hinging of the two frames in respect of each other and thereby an axial rotation of the rigid arm between the SPM-connection and the vessel-connection.

6. A mooring device as claimed in any of claims 1-5, in which the SPM consists of a buoy whose stationary part is anchored to the floor of said body of water by means of chains, cables or the like.

7. A mooring device as claimed in claim 1 or 2, in which the stationary part of the SPM consists of a pile system (tower or the like) standing on or in the sea bed around which pile system the rigid arm is rotatable.

8. The mooring system of claim 1-7, further comprising ballast weight (s) located in the rigid arm.

9. The mooring system of any of the preceding claims, wherein the tension members consist of chains or cables which can be suspended through the anchor chain hawses of the vessel.

10. The mooring device of any of the preceding claims, further comprising hinges between the buoy and the rigid arm.

11. The mooring device of any of the preceding claims, further comprising a buoyancy chamber in the rigid arm.

As may be seen from Fig. 2 the vessel 34 is moored to the floor of a body of water by means of two anchor chains 37, a rigid arm 36, a rotational table 38 and a structure ("tower") 31 rigidly attached to the seabed 33.

The rotating table 38 permits the vessel to swing freely around the tower 31 to take up the position of the least resistance to wind and weather. The rigid arm pivots in relation to this rotating table around an axis x-x, through hinges 41, thereby allowing independent pitch motions of the vessel relative to the tower.

Hinges at the rigid arm end 12 and at the vessel connection point 13 allow for excursions of the vessel due to surge and sway. Roll motions of the vessel relative to the tower are allowed by two basically triangular frames 14 and 15, which are coupled together at their base and hence form the rigid arm 36. The hinges 47 and 48 allow the rigid arm to be "folded" in itself, around axis y-y and thus allow independent roll between the tower side end of the rigid arm and the vessel side.

The restoring forces required to balance environmental forces acting on the tanker is generated by a weight 49 which forms a part of the rigid arm. This weight can be permanent or mobile, depending on the application of the mooring system.

The product is carried up the tower through rigid piping 50 to the top of the tower , where a fluid swivel mounted on a second rotating table 40 allows for orientation of the piping towards the vessel. The piping continues to the vessel in a manner described in patent application no. 81201274.8.

In Fig. 3 is shown another embodiment of the tower or pile system 31 of Fig. 2.

The tower 60 consists of a number of piles 61, which are slanting and which are unitary at the upper part or top 62 of the tower, but spread out in the lower region near the sea bottom 63. Around the upper part of the tower is mounted the rotatory part or rotor 64 of the SPM. This rotor 64 is connected to the rigid arm 66, the latter being connected with its other end via chains 67 to the vessel 68.

The product is carried up the tower through rigid piping (not shown) to the top 62 of the tower 60, where a fluid swivel 69

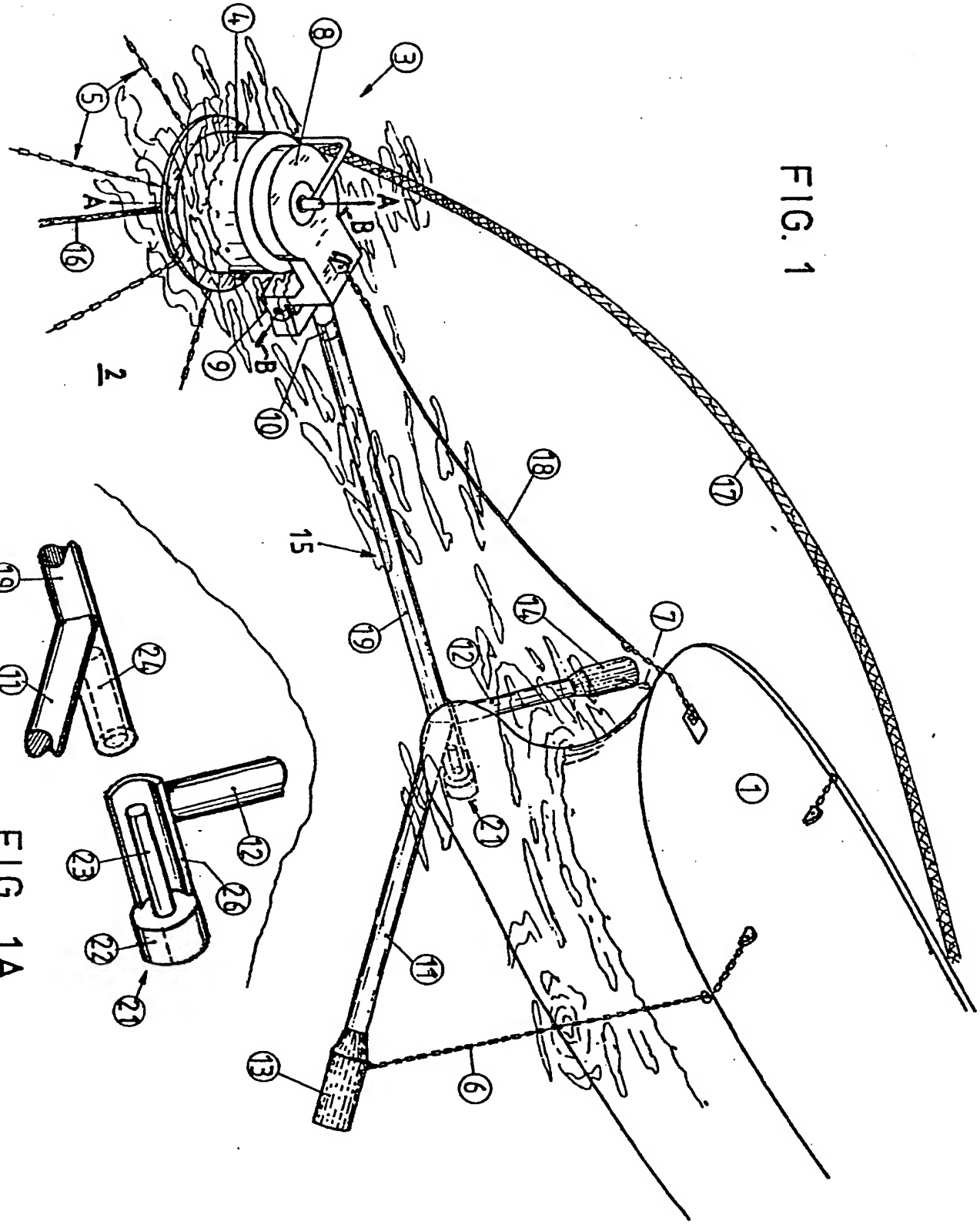


FIG. 1

FIG. 1A

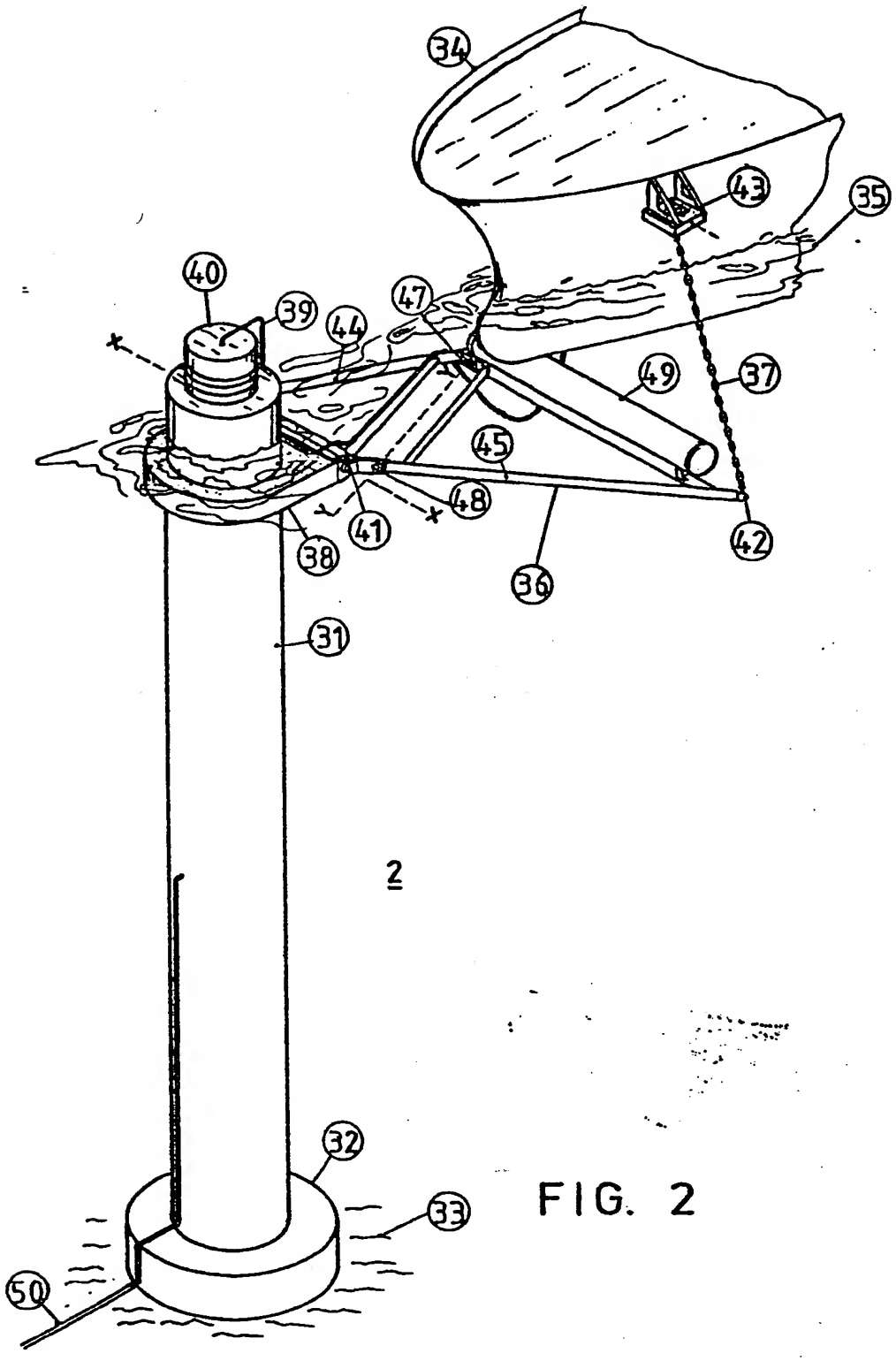


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FIG. 2

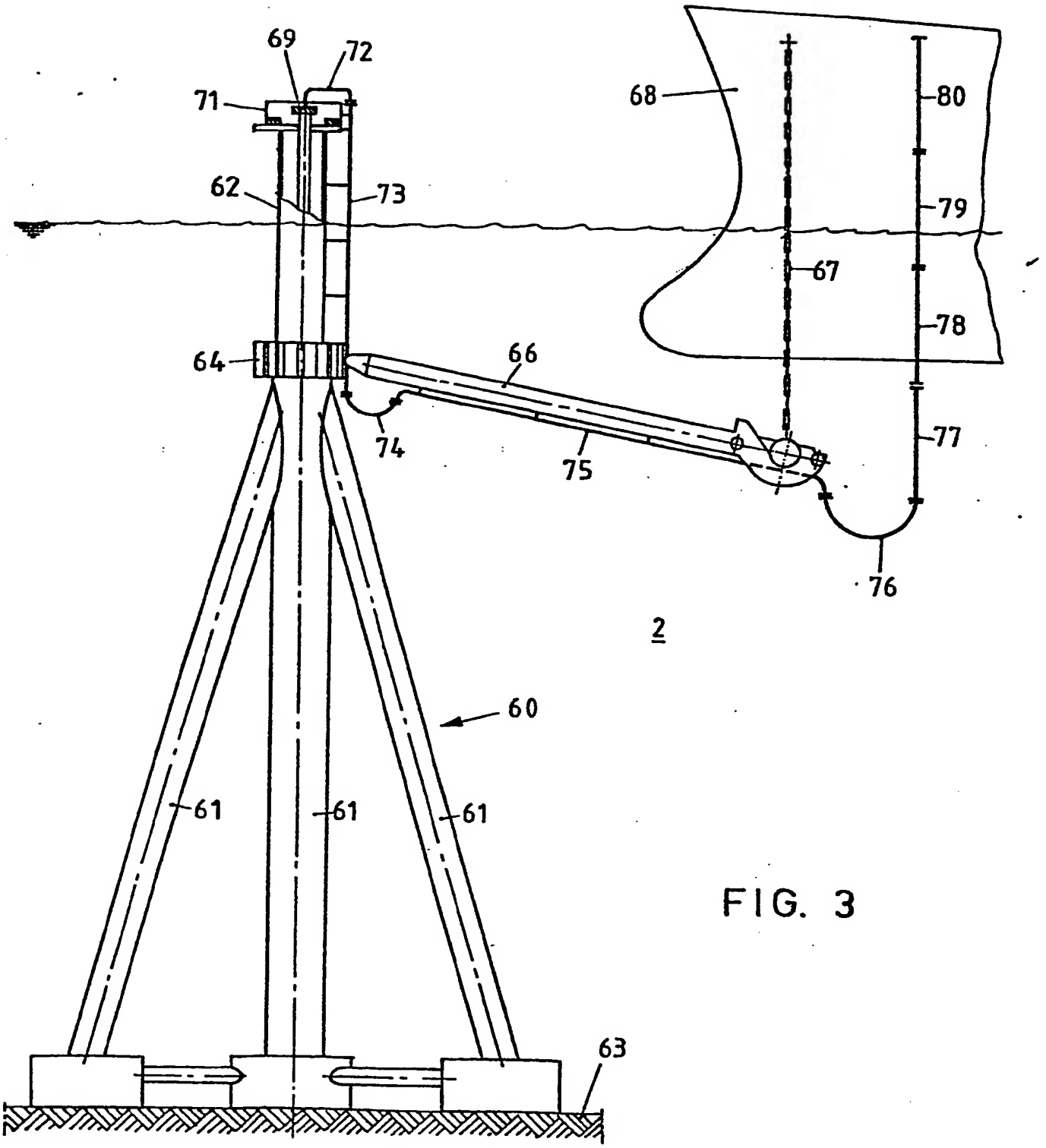

FIG. 3

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EUROPEAN SEARCH REPORT

Application number

EP 82 20 0724

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	FR-A-2 133 307 (ELF) *Page 3, line 30 - page 6, line 7; figures 1-6*	1,7,9, 10,11	B 63 B 21/52 B 63 B 27/34
A	US-A-4 176 615 (W.R.REID) *Column 2, lines 12-68; column 3; column 4, lines 1-24; figures 1-3*	1,2,6	
A	US-A-4 114 556 (J.A.ORNDORFF et al.) *Column 2, lines 27-68; column 3, lines 1-51; figures 1-7*	1,2,3, 10	
A	FR-A-2 418 146 (BLUEWATER TERMINAL SYSTEMS N.V.) *Page 3, lines 20-30; figure 1*	8,9	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	FR-A-2 420 475 (E.M.H.) *Page 3, line 17 - page 4, line 18; page 7, line 23 - page 8, line 19; figures 1,2,7,8*	8	B 63 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-02-1983	PRUSSEN J.R.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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